#32

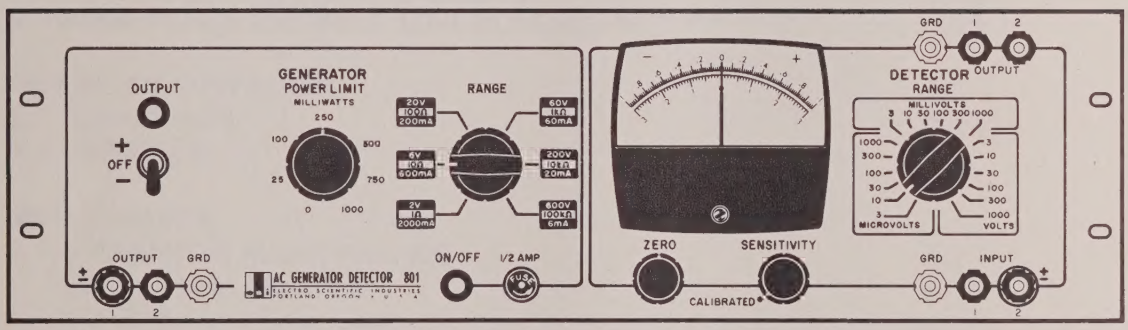
Instruction Manual

MARCH 1970

REPLACES AUGUST 1967

MODEL 801

DC GENERATOR-DETECTOR



SERIAL NUMBER: _____

PART NUMBER: 18403

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Electro Scientific Industries

13900 N. W. SCIENCE PARK DRIVE, PORTLAND, OREGON 97229

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ACKNOWLEDGMENTS

We wish to thank Hewlett-Packard Company for information concerning theory of operation, maintenance, schematic diagrams, and calibration and adjustment procedures for the detector. In particular, Sections 3.2, 4.2, 4.3, and 4.4 were adapted from the instruction manual for the Hewlett-Packard Model 419A DC Null Detector by permission of Hewlett-Packard.

SECTION I

INTRODUCTION

1.1 DESCRIPTION

The ESI Model 801 is a dc generator and null detector (microvoltmeter). The instrument features double-chassis construction, or guarding, to greatly reduce stray leakage paths to ground. Leakage from the high generator terminal and from the high detector terminals to ground has been virtually eliminated. Insulation of the other terminals is kept to 10^{11} ohms or greater.

The output of the generator is continuously variable and is limited to a maximum of one watt into a matched load. A front panel control selects six output impedance ranges to match loads from 1 ohm to 100 kilohms.

An active circuit line regulator reduces the effect of line transients by a factor of more than ten. Unique guarded relays that control generator power allow remote operation of the generator. In this way, an operator can control the generator with a foot switch or the instrument can be operated by automatic equipment. The generator output terminals are short-circuited when the generator is turned off, which inhibits transient pulses at the instant of turn-on.

The detector features a very sensitive modulator-type dc amplifier. Trouble caused by stray ac pickup from the device under test is greatly reduced by a rejection filter. The modulator operates above the ac line frequency, thus further reducing the ac pickup.

The double-chassis construction and complete integrity of guarding allow either the detector or the generator to be floated more than 600 volts above ground.

The unique design features of the Model 801 make it suitable to a number of applications:

1. Very high resistance bridge measurements can be made with superior accuracy because of the special guarding and shielding features, and because of line transient reduction.

2. Very low resistance bridge measurements can also be made with high accuracy because of the detector sensitivity and the provision for matching the generator to the load.

3. The same features apply to make the 801 an ideal generator-detector combination for calibrating precision voltage dividers. A detailed description of this application may be found in ESI's "Design Ideas", volume 1, number 1. See also Section 2.4 of this Manual.

4. The 801 can be used directly to measure extremely low conductance (high resistance). See Section 2.7.

5. The 801 generator can be used separately wherever a variable, guarded, and power-limited dc supply is needed.

6. The 801 detector can be used separately as a voltmeter or microvoltmeter with ranges up to 1,000 volts.

1.2 SPECIFICATIONS

1.2.1 Generator

Range: 6 ranges, continuously variable, 0 to 600V. Power limited to 1 watt.

Regulation: Active-circuit line regulator reduces effect of line transients by a factor of more than ten.

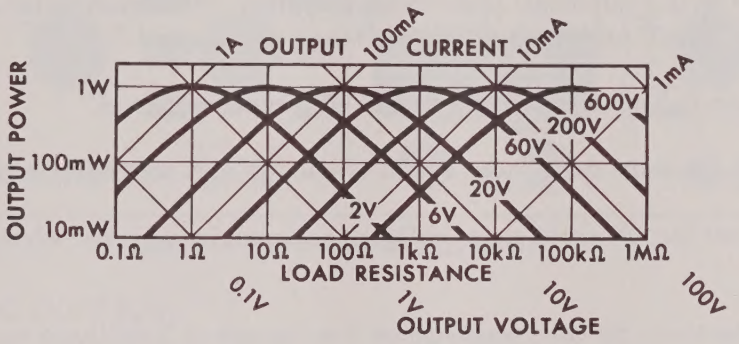

Figure 1.1 Maximum Output of 801 Generator

Insulation Resistance: Terminal 1 greater than 10^{14} ohms;
Terminal 2 greater than 10^{11} ohms;

Output Resistance:

OPEN CIRCUIT VOLTAGE (VOLTS)	2	6	20	60	200	600
SHORT CIRCUIT CURRENT (mA)	2000	600	200	60	20	6
OUTPUT RESISTANCE (OHMS)	1	10	100	1k	10k	100k

1.2.2 Detector

Ranges: Calibrated ±3 microvolts to ±1000 volts dc end scale in 18 zero-center ranges, sensitivity (uncalibrated) can be increased to about 0.75 microvolt end scale.

Accuracy: ±5 percent of end scale, ±0.1 microvolt.

Limits of Zero Control: ±15 microvolts.

Input Resistance: 3-microvolt to 3-millivolt ranges: 100 kilohms.
10-millivolt to 30-millivolt ranges: 1 megohm.
100-millivolt to 300-millivolt ranges: 10 megohms.
1-volt to 1000-volt ranges: 100 megohms.

Response Time: 95 percent of final reading within 4 sec on the 3-microvolt range. 95 percent of final readings within 1.5 sec on the 10-microvolt to 1000-volt ranges.

Superimposed AC Rejection: With frequencies of 60 Hz (cps) or higher (except modulator frequency: 160 to 170 Hz), ac voltages that are 80 dB greater than the end scale will affect the reading less than 2 percent. (AC voltage must be limited to 300 volts rms.)

Noise: Less than 0.1 microvolt peak-to-peak typical. Maximum meter excursion will be 0.2 microvolt peak-to-peak in any ten-second period.

Drift: Less than 0.5 microvolt per day after 30 minutes warm-up.

Gain: 110 dB maximum at recorder output terminals (gain depends on range).

Output: ±1 volt for full scale meter deflection; approximately 750 microamperes maximum.

Overload Protection: 50 volts maximum on 3-microvolt to 3 millivolt ranges; 500 volts maximum on 10-millivolt to 300-millivolt ranges; 1200 volts maximum on 1-volt range and above. Regardless of voltage limitations, the full output of the generator (approximately 600 volts) cannot damage the detector, even on the most sensitive range.

Overload Recovery Time: Meter indicates within 4 seconds for a 10^6 overload with input shorted; less than 15 seconds with input open.

Input Isolation: 10^{11} ohms shunted by 250 picofarads. May be operated more than 600 volts dc or 350 volts ac (rms) above ground.

1.2.3 Physical

Height:	5 1/4 inches	(13.3 cm)
Length:	19 inches	(48.25 cm)
Depth:	11 inches	(25.7 cm)
Weight:	21 pounds	(9.5 kg)

Power requirements: 117 or 230 volts selected by internal switch, 50 to 400 Hz (cps), 15 watts.

SECTION II

OPERATING INSTRUCTIONS

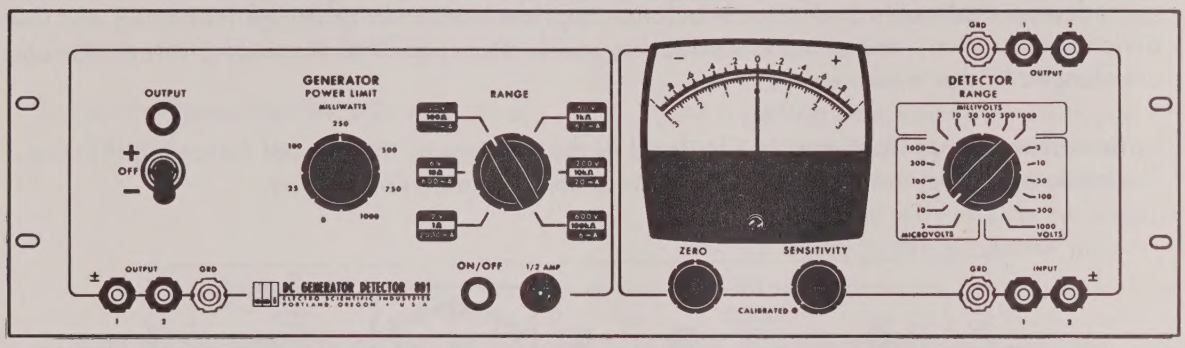

Figure 2.1 Terminals and Controls

2.1 TERMINALS AND CONTROLS

Generator OUTPUT Terminals: The lower left-hand terminals are for connecting the generator to an external circuit.

Detector INPUT Terminals: The lower right-hand terminals are for connecting the detector to an external circuit.

Detector OUTPUT Terminals: The upper right-hand terminals are provided so an external meter or recorder may be conveniently connected to the detector.

Detector ZERO Control: Adjusts the detector zero.

Detector RANGE Selector: Selects the sensitivity range of the detector.

Detector SENSITIVITY Control: Continuously varies the detector sensitivity from a minimum at the CALIBRATED position to a maximum of about four times the end-scale sensitivity indicated by the RANGE selector.

Generator POWER LIMIT Control: Varies the power limit level of the generator from 0 to 1 watt maximum.

Generator RANGE Selector: Selects the generator limiting resistor, the maximum (open circuit) voltage, and maximum (short circuit) current.

Generator OUTPUT Switch: Connects the generator output of the selected polarity to the OUTPUT terminals.

ON/OFF Switch: Controls line power to both generator and detector.

2.2 BASIC OPERATING PROCEDURE

This section describes the basic procedure for using the Model 801 to test or adjust any three-terminal or four-terminal resistive circuit by applying the generator output to one pair of terminals and observing the resulting signal at another pair of terminals with the detector. The procedure is applicable both to null balance applications, such as bridge balancing and voltage divider calibration, and to meter deflection applications, such as ohmmeter, attenuator and unbalanced bridge measurement.

Various specific applications are discussed in the sections of the manual following this one. The basic operating procedure for all of these applications is as follows:

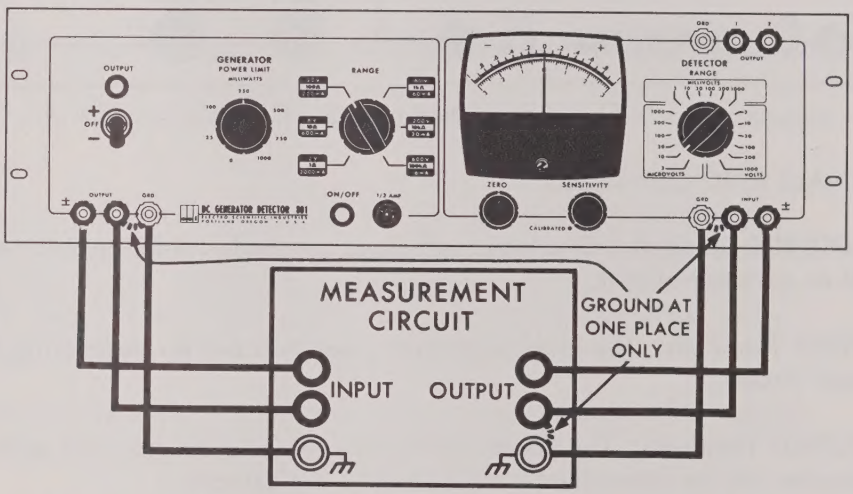

Figure 2.2 Basic Operating Procedure

1. Be sure the generator OUTPUT switch is off, then turn the ON/OFF switch on and allow time for warmup.

2. Connect the measurement circuit to the generator OUTPUT and detector INPUT terminals as shown in Figure 2.2.

   The measurement circuit should be grounded at one point only, so that ground loop currents between chassis cannot flow through these leads.

3. Set the detector SENSITIVITY control at CALIBRATED.

   This adjusts full scale indication to the range setting.

4. Set the detector RANGE switch at 3 microvolts and adjust the ZERO control for meter zero.

   Always adjust zero with detector input connected to the measurement circuit - not open or short circuited - in order to cancel effects causing zero shift with change in source resistance.

5. Change the detector RANGE switch to a range higher than the voltage expected when the generator is first turned on.	This will avoid meter recovery delays caused by input signals greater than full scale.
6. Set the generator POWER LIMIT control to a value which will not cause resistance changes due to heating.	A power setting lower than the lowest-rated resistor in the measurement circuit is always safe.
7. Set the generator RANGE control as desired.	At a setting most nearly equal to the input resistance of the measurement circuit, the generator output will be a maximum, and will usually be approximately equal to the generator power setting.
8. Turn on the generator by setting the OUTPUT switch as desired; the marking indicates the polarity of OUTPUT terminal 1.	The detector polarity is fixed, the direction of the meter deflection corresponding to the polarity of INPUT terminal 2.
9. Adjust the generator POWER LIMIT and RANGE controls as required. For maximum power find the generator RANGE setting giving maximum detector deflection. To reduce the power below the generator POWER LIMIT setting, use generator RANGE settings away from the maximum setting - both voltage and current will be reduced as a result of resistance mismatch in either direction.	For further reduction of power, connect either a low-value shunt resistor across the generator OUTPUT terminals 1 and 2 or a high-value series resistor in the OUTPUT 1 lead, and use a generator RANGE setting far away from the value of the shunt or series resistor.
10. Change the detector RANGE setting as required for detector sensitivity. Use the SENSITIVITY control to increase the detector sensitivity above the calibrated detector RANGE setting.	Turn off the generator OUTPUT switch and recheck detector ZERO adjustment each time detector RANGE is changed toward higher sensitivity.
11. Take as the final meter reading the change in reading with generator on and generator off (or half the change with generator polarity reversal), to eliminate the effect of imperfect zero adjustment.	Take readings after switching transients have disappeared (normally within one second after turning generator on or off). For maximum sensitivity in null balance applications, generator power can often be increased for final adjustment if generator OUTPUT switch is left on only a few seconds at a time to minimize resistor heating.

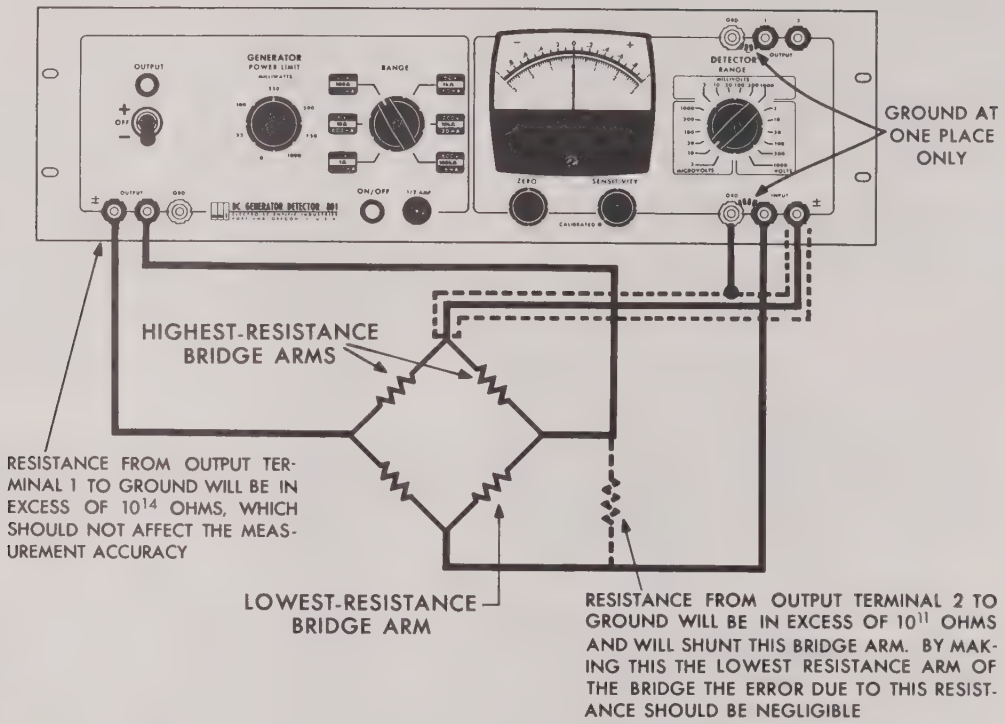
GROUND AT ONE PLACE ONLY
HIGHEST-RESISTANCE BRIDGE ARMS
RESISTANCE FROM OUTPUT TERMINAL 1 TO GROUND WILL BE IN EXCESS OF 10^{14} OHMS, WHICH SHOULD NOT AFFECT THE MEASUREMENT ACCURACY
LOWEST-RESISTANCE BRIDGE ARM
RESISTANCE FROM OUTPUT TERMINAL 2 TO GROUND WILL BE IN EXCESS OF 10^{11} OHMS AND WILL SHUNT THIS BRIDGE ARM. BY MAKING THIS THE LOWEST RESISTANCE ARM OF THE BRIDGE THE ERROR DUE TO THIS RESISTANCE SHOULD BE NEGLIGIBLE

Figure 2.3 Bridge Measurement Connection

Connect the bridge to the generator OUTPUT and detector INPUT terminals as shown in Figure 2.3, then balance bridge following basic operating procedure of Section 2.2.

2.4 USING THE 801 FOR VOLTAGE DIVIDER CALIBRATION

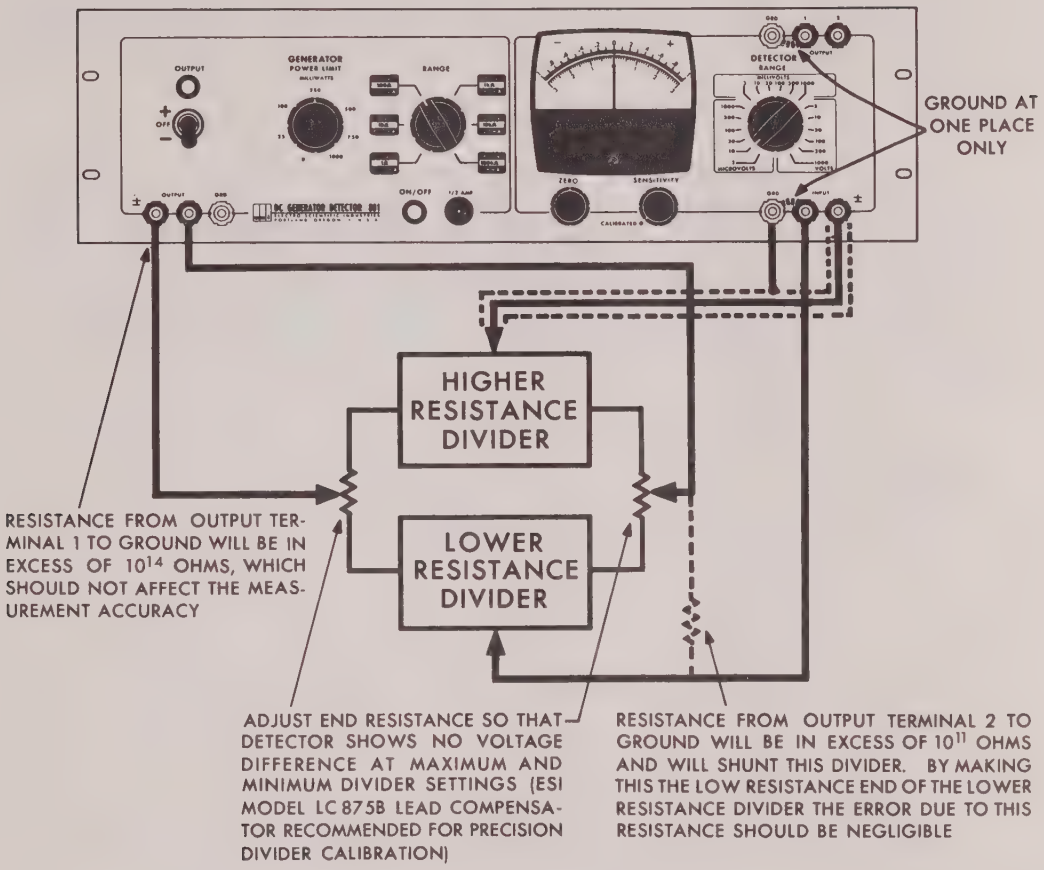
GROUND AT ONE PLACE ONLY
HIGHER RESISTANCE DIVIDER
LOWER RESISTANCE DIVIDER
RESISTANCE FROM OUTPUT TERMINAL 1 TO GROUND WILL BE IN EXCESS OF 10^{14} OHMS, WHICH SHOULD NOT AFFECT THE MEASUREMENT ACCURACY
ADJUST END RESISTANCE SO THAT DETECTOR SHOWS NO VOLTAGE DIFFERENCE AT MAXIMUM AND MINIMUM DIVIDER SETTINGS (ESI MODEL LC 875B LEAD COMPENSATOR RECOMMENDED FOR PRECISION DIVIDER CALIBRATION)
RESISTANCE FROM OUTPUT TERMINAL 2 TO GROUND WILL BE IN EXCESS OF 10^{11} OHMS AND WILL SHUNT THIS DIVIDER. BY MAKING THIS THE LOW RESISTANCE END OF THE LOWER RESISTANCE DIVIDER THE ERROR DUE TO THIS RESISTANCE SHOULD BE NEGLIGIBLE

Figure 2.4 Voltage Divider Connection

Connect the pair of dividers or attenuators to the generator OUTPUT and detector INPUT terminals as shown in Figure 2.4, then adjust to find pairs of settings giving detector null indications, following the basic operating procedure of Section 2.2.

2.5 USING THE 801 FOR TOLERANCE CHECKING BY DEFLECTION

Where repeated measurements are to be made to detect small variations of a resistive circuit from a standard value, meter deflection methods can save a great deal of time. Such applications are the checking of batches of resistors for accuracy, the calibration of voltage dividers where an exact null balance is not convenient, or the testing of resistors or resistive networks for changes with temperature or other ambient conditions.

For such deflection measurements, use the appropriate bridge or divider connection as discussed in Sections 2.3 and 2.4. Follow the basic procedure of Section 2.2 in the initial adjustment of the circuit. At steps 9 and 10, adjust the generator POWER LIMIT or the detector RANGE and SENSITIVITY controls so that a small change in the bridge or divider setting produces a conveniently related number of divisions of meter change. Now adjust the bridge or standard divider for a meter null at the standard value and read changes from this value in terms of meter deflection.

2.6 USING THE 801 AS AN ULTRA-LOW RESISTANCE OHMMETER

To measure the approximate value of a very low resistance, such as a switch or relay contact or a piece of wire, use the circuit shown in Figure 2.5.

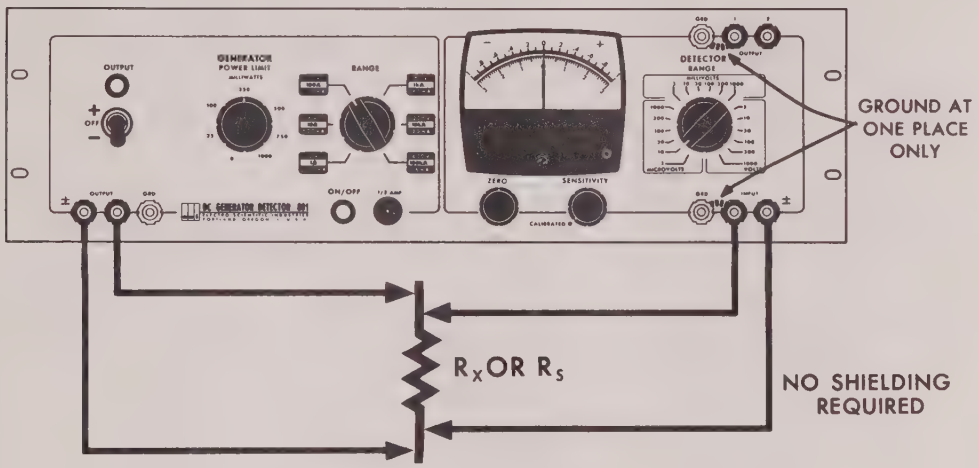

Figure 2.5 Low Resistance Measurement

Follow the basic procedure of Section 2.2 with the following additions:

For ±20 percent accuracy:

1. Before connecting the unknown resistance, connect the detector INPUT leads directly to the generator OUTPUT leads.

2. Set the generator RANGE resistance to a value at least 10 times the value of the unknown resistor.

3. Adjust generator POWER LIMIT so that the voltage reading is an exact power of 10. Call this voltage reading E_G.

4. Connect the unknown resistor R_x in the circuit of Figure 2.5.

5. Leaving generator RANGE and POWER settings alone, but changing detector RANGE as required, measure the voltage. (Be sure that SENSITIVITY control is set to CALIBRATED.) Call this voltage reading E_x.

6. Calculate the unknown resistance value from the formula:

$$\frac{R_x}{E_x} = \frac{\text{Generator RANGE Resistance Setting}}{E_G}$$

For ±5 percent accuracy:

1. Connect a known standard resistor, having a value R_s not greater than 1000 ohms, in the circuit of Figure 2.5.

2. Set the generator RANGE to a value at least 100 times the value of the standard resistor.

3. Adjust generator POWER LIMIT so that the voltage reading is conveniently related to the standard resistance value. Call this voltage reading E_s.

4. Remove the standard resistor and connect the unknown resistor R_x.

5. Leaving generator RANGE and POWER LIMIT settings alone, but changing detector RANGE as required, measure the voltage. Call this voltage reading E_x.

6. Calculate the unknown resistance value from the formula:

$$\frac{R_x}{E_x} = \frac{R_s}{E_s}$$

2.7 USING THE 801 AS AN ULTRA-HIGH RESISTANCE OHMMETER

To measure the approximate value of a very high resistance, such as the leakage in an insulator, use the circuit shown in Figure 2.6.

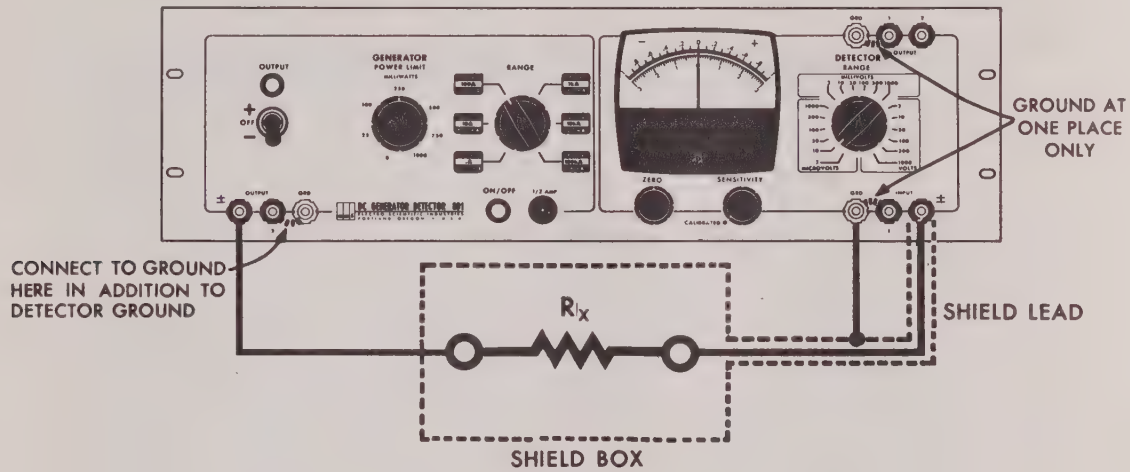

Figure 2.6 High-Resistance Measurement

Follow the basic procedure of Section 2.2 with the following additions:

1. Before connecting the unknown resistance, connect the detector INPUT 2 lead to the generator OUTPUT 1 lead (or connect a short circuit across the unknown resistance).

2. Set generator RANGE to 100 kilohms.

3. Set generator OUTPUT switch either to + or - position and adjust POWER LIMIT control for a detector reading of 500 volts. (Other voltages may be used, but the conversion chart, Figure 2.7, is intended for use with a 500-volt setting.)

4. Connect the unknown resistance R_x in the circuit of Figure 2.6.

5. Leaving the generator RANGE and POWER LIMIT settings alone, but changing detector RANGE as required, measure the voltage. Call this voltage reading E_x.

6. Use the conversion chart, Figure 2.7, to convert the voltage reading to the resistance. (If a voltage other than 500 volts was used in Step 3, use the following conversion formula:

$$R_x = \frac{E_g R_d}{E_x} - R_d$$

where R_x is the unknown resistance,
E_g is the generator voltage,

R_d is the detector resistance, which depends on the RANGE setting:

3 MICROVOLTS to 3 MILLIVOLTS; 100 kilohms
10 MILLIVOLTS to 30 MILLIVOLTS; 1 megohm
100 MILLIVOLTS to 300 MILLIVOLTS; 10 megohms
1000 MILLIVOLTS to 1000 VOLTS; 100 megohms.)

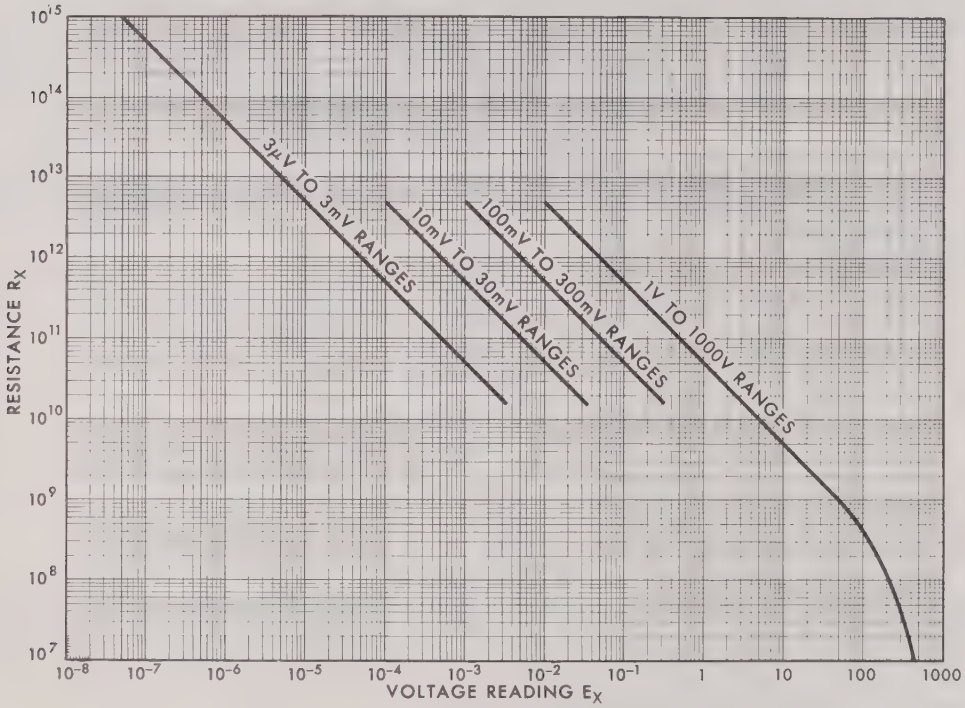

Figure 2.7 Voltage to Resistance Conversion Chart

2.8 USING THE 801 AS A VOLTMETER

To use the Model 801 detector as a voltmeter, connect the voltage to be measured to the detector INPUT terminals, set the SENSITIVITY control to CALIBRATED, and set the RANGE selector to the appropriate voltage range. If there is any doubt about the voltage, use a higher range first and then decrease it.

The voltage (times the range factor) is indicated on the meter. The polarity marked on the meter is the polarity of the voltage connected to INPUT terminal 2.

2.9 REMOTE GENERATOR OPERATION

The generator output is controlled by two unique guarded relays that are controlled either by the OUTPUT switch or by remote switches. A terminal board in the back of the instrument is supplied to connect remote switches such as foot-operated switches or automatic sequencing equipment.

In order to apply a positive voltage to OUTPUT terminal 1, a remote switch must be connected to short-circuit the + and the COM terminals in the rear of the instrument. Similarly, to apply a negative voltage, a remote switch must short-circuit the - and the COM terminals.

There is no necessity to prevent simultaneous connections; if both terminals in the rear are short-circuited to COM or if, for example, the - terminal is connected to the COM terminal and the OUTPUT switch is set to + , no damage will be done since the relays will disconnect the generator when they are both energized.

Figure 2.8 is a simplified schematic of the generator control circuits.

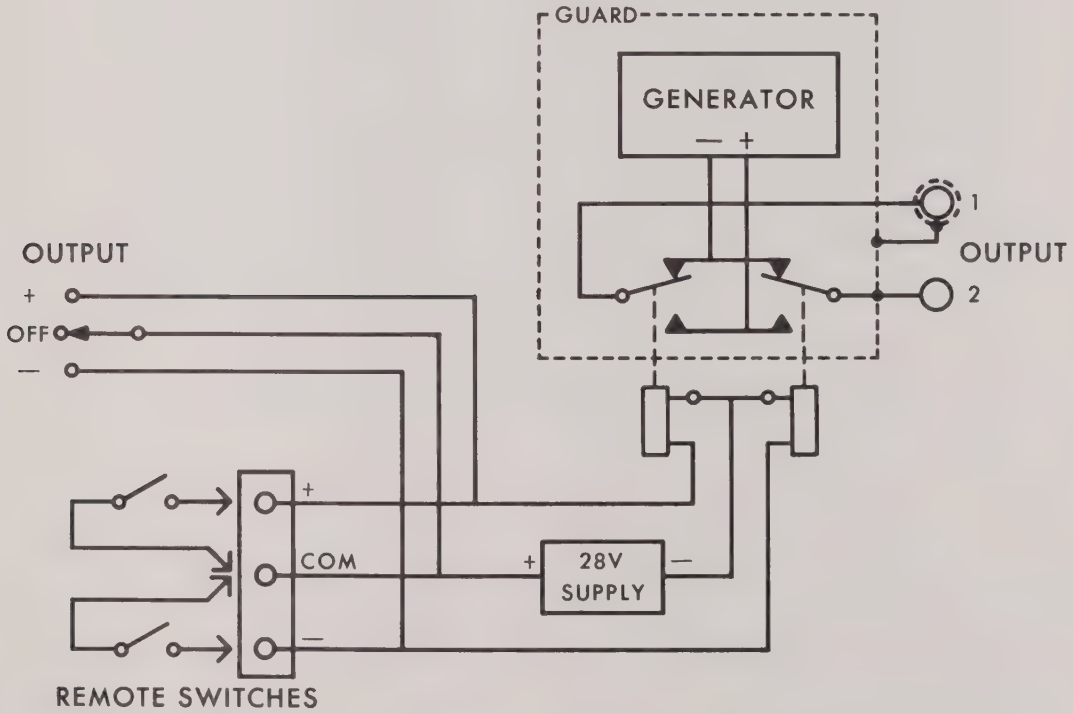

Figure 2.8 Remote Generator Control

2.10 CHANGING THE INPUT LINE VOLTAGE

The Model 801 Generator-Detector may be operated on either 117-volt or 230-volt ac power. An internal switch selects the input wiring to accommodate either voltage.

The setting of this switch at the time of manufacture is noted on the rear of the instrument. If the setting of the switch is not correct for the power line to be used, change the setting of the switch before plugging in the instrument.

In order to have access to the switch, remove the instrument case (paragraph 4.1.2). The switch is located on a chassis support immediately behind the upper center of the front panel. Slide the switch with a fingernail or with a small screwdriver so that it indicates 115 or 230 as appropriate.

Replace the instrument case after setting the switch, and correct the note attached to the rear of the instrument.

SECTION III

THEORY OF OPERATION

3.1 GENERATOR

The 801 generator is a line-regulated, guarded dc power supply with variable output power and a provision for matching the output impedance to a wide range of values. The guarding of the generator makes accurate high-resistance bridge measurements possible. The diagrams below illustrate how this is done.

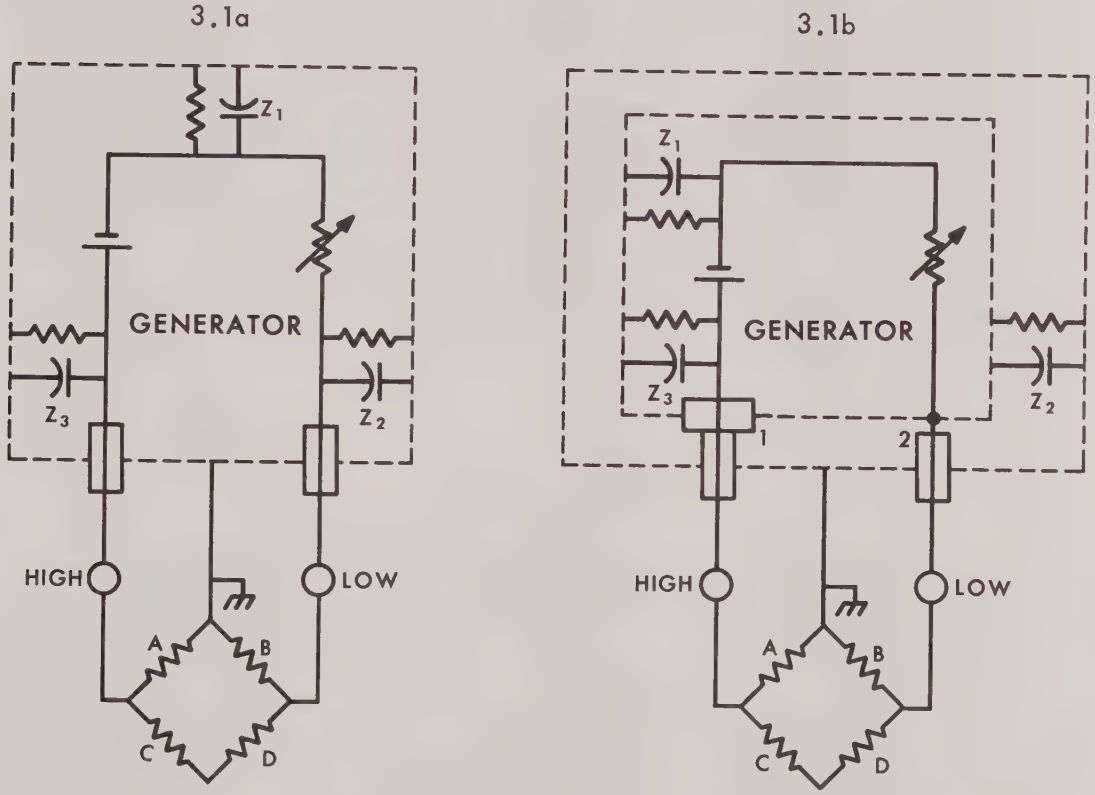

Figure 3.1 Generator Circuits

In the unguarded circuit shown in Figure 3.1a, the leakage impedances Z_2 and Z_3 appear in parallel with bridge arms A and B. If these were high-resistance arms, an appreciable error would result. The leakage impedance Z_1 is also in parallel with each of arms A and B. Since this leakage is at a higher emf than those at the terminals, it will cause even more error.

The 801 generator uses the guarded circuit as shown in Figure 3.1b. Z_1 and Z_3 appear in parallel with the generator, and cause no trouble. Z_2 is kept to better than 10^{11} ohms by use of high quality insulators, both as a feed-through insulator for the low terminal and as

support insulators for the guard chassis. By keeping bridge arm B (or whatever resistance is attached to the low terminal) small relative to 10^{11} ohms, no appreciable error is experienced. The guarding also keeps any ac voltage across Z_1 from getting into the detector via bridge arms A and B, since this ac voltage is returned to the low terminal.

The primary of the power transformer is separately shielded and air-insulated from the core to prevent capacitive coupling and leakage of ac voltages to the guard chassis. If an ac voltage were present on the guard chassis, it would appear from the low output terminal to ground and, thus, directly across the bridge arm B (Figure 3.1) in bridge measurements. The ac would then appear on the detector and would cause an error in null reading. The separate shielding of the transformer is connected to ground to prevent this error.

The generator is line-operated and has a solid-state line voltage regulator. The input voltage, which may be 117 volts or 230 volts ac, is increased (if necessary) by the input transformer to 230 volts. This voltage is clipped by the line regulator to 117 volts, which is applied to a continuously-variable autotransformer. The autotransformer output is applied to a high-isolation guarded transformer which supplies power to the rectifier and filter networks. Filtered dc is supplied to the output terminals through various resistances. The resistances and output voltages are selected by the generator RANGE selector. Each voltage and resistance combination is calculated to allow no more than one watt in any measurement circuit connected to the generator terminals.

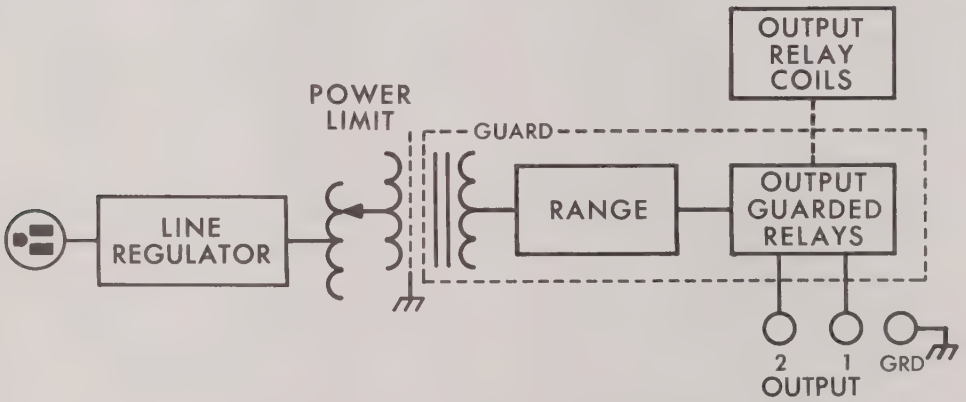

Figure 3.2 Generator Simplified Circuit

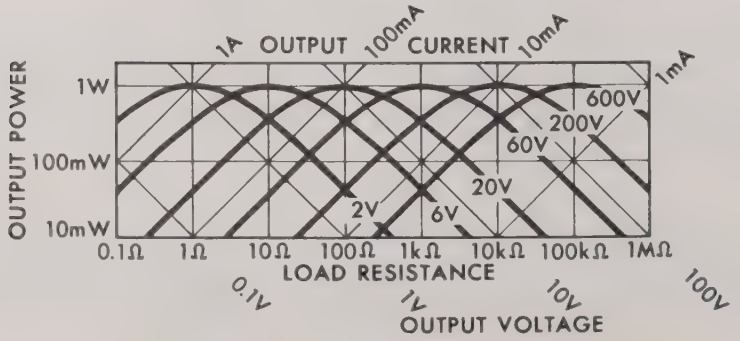

Figure 3.3 Generator Output

3.2 DETECTOR

The detector of the Model 801 is a high-sensitivity solid-state dc voltmeter. It has the following basic circuits: (1) an input attenuator, (2) a modulator and demodulator, (3) an ac amplifier, (4) a dc amplifier, (5) a meter, and (6) a feedback control circuit. Figure 3.4 is a block diagram of the detector.

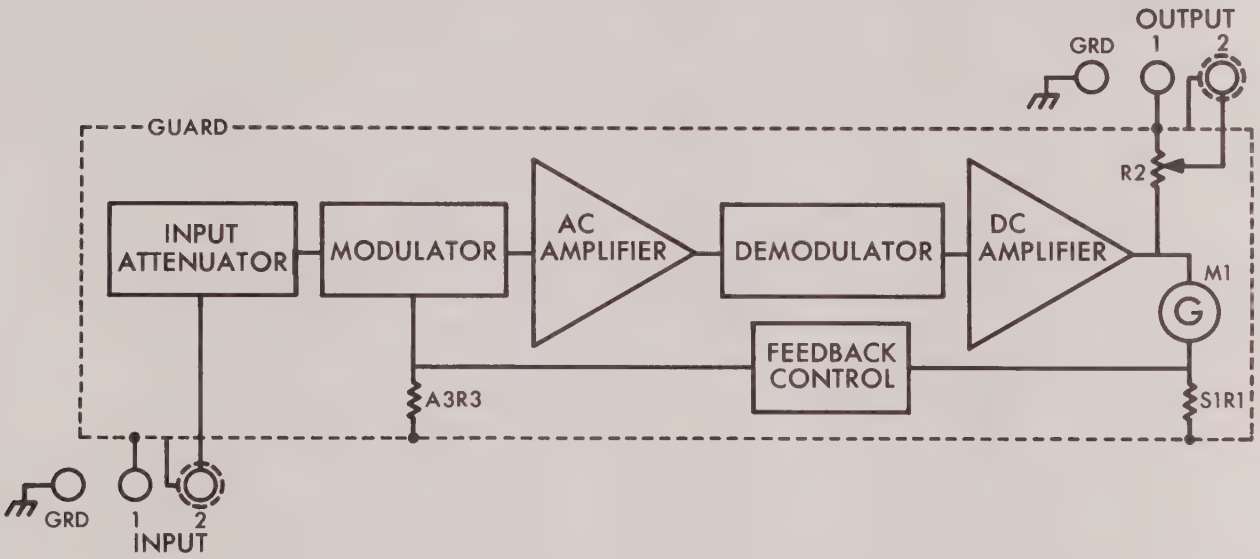

Figure 3.4 Detector Block Diagram

A dc voltage measured by the detector is applied to the input attenuator, which is a resistive divider operated by the RANGE switch. Table 3.1 lists the attenuation factors for each range.

The dc output of the input attenuator is modulated by the modulator, which consists of two photocells that are alternately illuminated by two neon lamps. The output of the modulator is a square wave with an amplitude that is proportional to the amplitude of the dc input voltage.

The square wave output of the modulator is amplified by a six-stage, high-gain ac amplifier. The output of the ac amplifier is applied to the demodulator. The demodulator output is a dc voltage with an amplitude proportional to the square-wave output of the ac amplifier. The output of the demodulator is applied to a three-stage dc voltage and power amplifier. The gain provided by the ac and dc amplifiers is listed for each range in Table 3.1.

The output of the dc amplifier, approximately 1 volt full scale, is applied to the meter and to the OUTPUT terminals on the front of the panel.

The feedback control circuit consists of a resistive voltage divider controlled by the RANGE switch and a SENSITIVITY control. When the SENSITIVITY control is in the CALIBRATED

position, it is disconnected, and only the voltage divider has any effect. The feedback provided by the feedback control circuit with SENSITIVITY at CALIBRATED is listed for each range in Table 3.1. Subtracting the feedback from the open-loop gain gives the closed-loop gain. The closed-loop gain, in conjunction with the input attenuation factor provides 18 calibrated full scale ranges from 3 microvolts to 1000 volts. When the SENSITIVITY control is not in the CALIBRATED position, it reduces the feedback and thus increases the closed-loop gain. By thus reducing the feedback, the sensitivity of the detector can be increased to about four times the calibrated sensitivity.

Table 3.1 Amplifier Characteristics

RANGE	ATTENUATION FACTOR	OPEN LOOP GAIN	FEEDBACK
3 μV	1:1	150 dB	40 dB
10 μV	1:1	150 dB	50 dB
30 μV	1:1	150 dB	60 dB
100 μV	1:1	150 dB	70 dB
300 μV	1:1	130 dB	60 dB
1000 μV	1:1	130 dB	70 dB
3 mV	1:1	120 dB	70 dB
10 mV	10:1	120 dB	60 dB
30 mV	10:1	120 dB	70 dB
100 mV	10^2:1	120 dB	60 dB
300 mV	10^2:1	120 dB	70 dB
1000 mV	10^3:1	120 dB	60 dB
3 V	10^3:1	120 dB	70 dB
10 V	10^4:1	120 dB	60 dB
30 V	10^4:1	120 dB	70 dB
100 V	10^5:1	120 dB	60 dB
300 V	10^5:1	120 dB	70 dB
1000 V	10^6:1	120 dB	60 dB

SECTION IV

MAINTENANCE

4.1 PREVENTIVE MAINTENANCE

The following procedures should be performed periodically (approximately once a year) to insure maximum accuracy and reliability from the Model 801 Generator-Detector.

If the need for major repairs is apparent, it is recommended that the unit be sent to the factory for service. The service department will be glad to furnish the necessary information for repairs as well as any replacement parts. However, unauthorized repairs will invalidate the instrument warranty.

4.1.1 Visual Inspection

Inspect the unit for dial orientation and damage to binding posts and binding post caps. Also check for dirt around the binding post insulators. Then remove the case as described in Paragraph 4.1.2 and inspect the unit for possible internal defects. These defects include such things as loose or broken connections, damaged or dirty switch contacts, and heat-damaged resistors.

4.1.2 Removing the Case

Prepare a soft, clean place to set the instrument. Be sure that no projections or pointed objects will be underneath the panel. See that there are no metal filings in the area.

Place the unit face down on the prepared surface. Remove the screws on the back of the instrument and carefully slide the case off.

4.1.3 Cleaning and Lubrication

Clean the front panel with a soft, dry, lint-free cloth, being particularly careful to remove all dirt from around the binding post insulators. The only internal components that require cleaning and lubrication are the switches.

The switches are carefully lubricated at the time of manufacture and are protected from contamination by the instrument case. They should rarely, if ever, require maintenance. It is recommended that they be cleaned or lubricated only if it is determined that they are not making good electrical contact. If the switch decks are in need of cleaning or lubrication, proceed as follows:

a) Apply solvent (Freon printed circuit solvent or equivalent) to the contact surfaces with a small brush or pipe cleaner.

b) Wipe surfaces with clean, dry brush or dry with low-pressure air.

c) Apply a thin coating of lubricant (Oak #2008 or equivalent) to the contact surfaces with a hypodermic needle.

d) Apply two drops of the same oil to each of the switch bearings and detent mechanisms.

e) Remove excess oil with a clean, dry cloth and remove all traces of lint with a soft brush.

4.1.4 Replacing the Case

Be sure that the interior of the case is completely clear of all foreign material. Slip the case over the unit and replace the screws.

4.2 PERFORMANCE TESTS

The performance tests presented in this section are front panel procedures designed to compare the Model 801 with its published specifications. These tests may be incorporated in periodic maintenance, post repair, and incoming quality control inspection. These tests should be conducted before any attempt is made at instrument calibration.

The test equipment required for maintenance of the Model 801 is listed in Table 4.1. Equipment having similar characteristics may be substituted for the equipment listed.

Table 4.1 Test Equipment Required

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
Potentiometric Voltmeter	DC Voltage Range: 1 μV to 500 V Accuracy: ±0.2%	Accuracy Test, Response Test, and Alignment	ESI Model 300 PVB®

4.2.1 Accuracy Performance Test

The accuracy performance test setup is illustrated in Figure 4.1.

a) Connect test setup illustrated in Figure 4.1a and set potentiometric voltmeter to operate as a voltage source.

b) Make control settings indicated in Step 1 of Table 4.2. If detector reading is not within tolerances listed, perform full-scale calibration procedure (paragraph 4.4.3).

c) Repeat Step b for Steps 1 through 13 in Table 4.2.

d) Connect a wire from generator OUTPUT terminal 1 to detector INPUT terminal 2, and a wire from generator OUTPUT terminal 2 to detector INPUT terminal 1. See Figure 4.1b.

e) Set the potentiometric voltmeter to measure voltage.

f) Make the control settings indicated in Step 14 of Table 4.2 and adjust generator POWER LIMIT and RANGE controls to null the potentiometric voltmeter. If detector reading is not within tolerances listed, perform full-scale calibration procedure (paragraph 4.4.3).

g) Repeat Step f for Steps 14 through 18 in Table 4.2.

Table 4.2 Accuracy Performance Test

STEP	POTENTIOMETRIC VOLTMETER SETTINGS		MODEL 801	
	MULTIPLIER	DECADE DIALS	DETECTOR RANGE	DETECTOR READING
1	VOLTS × 0.01	0.0003	3 μV	2.75 to 3.35
2	VOLTS × 0.1	0.0001	10 μV	9.40 to 10.60
3	VOLTS × 0.1	0.0003	30 μV	2.84 to 3.16
4	VOLTS × 0.1	0.0010	100 μV	9.49 to 10.51
5	VOLTS × 0.1	0.0030	300 μV	2.85 to 3.15
6	VOLTS × 1	0.0010	1000 μV	9.50 to 10.50
7	VOLTS × 1	0.0030	3 mV	2.85 to 3.15
8	VOLTS × 1	0.0100	10 mV	9.50 to 10.50
9	VOLTS × 1	0.0300	30 mV	2.85 to 3.15
10	VOLTS × 1	0.1000	100 mV	9.50 to 10.50
11	VOLTS × 1	0.3000	300 mV	2.85 to 3.15
12	VOLTS × 1	1.0000	1000 mV	9.50 to 10.50
13	VOLTS × 1	3.0000	3 V	2.85 to 3.15
14	VOLTS × 10	1.0000	10 V	9.50 to 10.50
15	VOLTS × 10	3.0000	30 V	2.85 to 3.15
16	VOLTS × 100	1.0000	100 V	9.50 to 10.50
17	VOLTS × 100	3.0000	300 V	2.85 to 3.15
18	VOLTS × 100	5.0000	1000 V	4.50 to 5.50

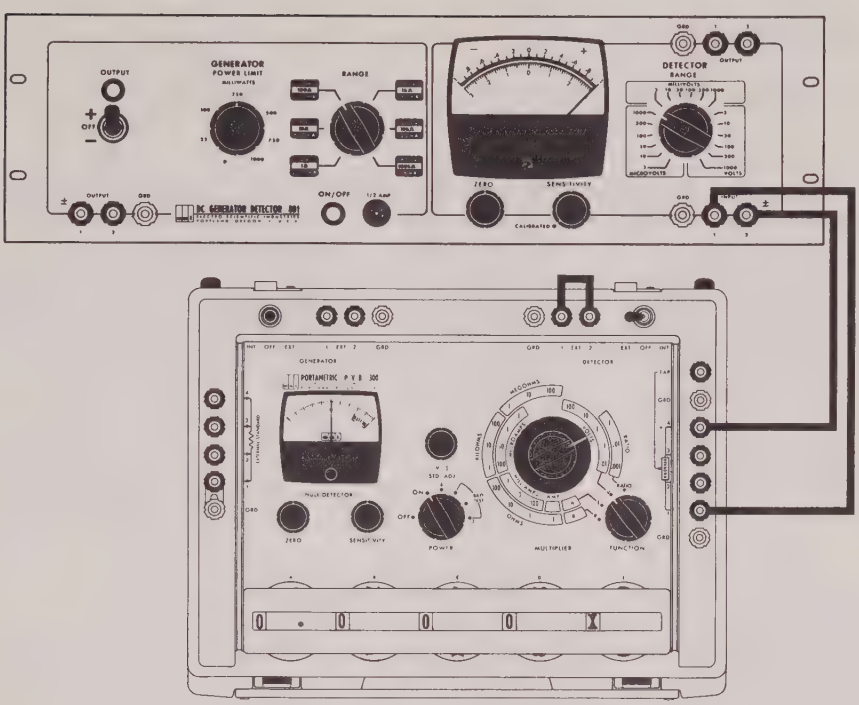

Figure 4.1a Detector Accuracy Test

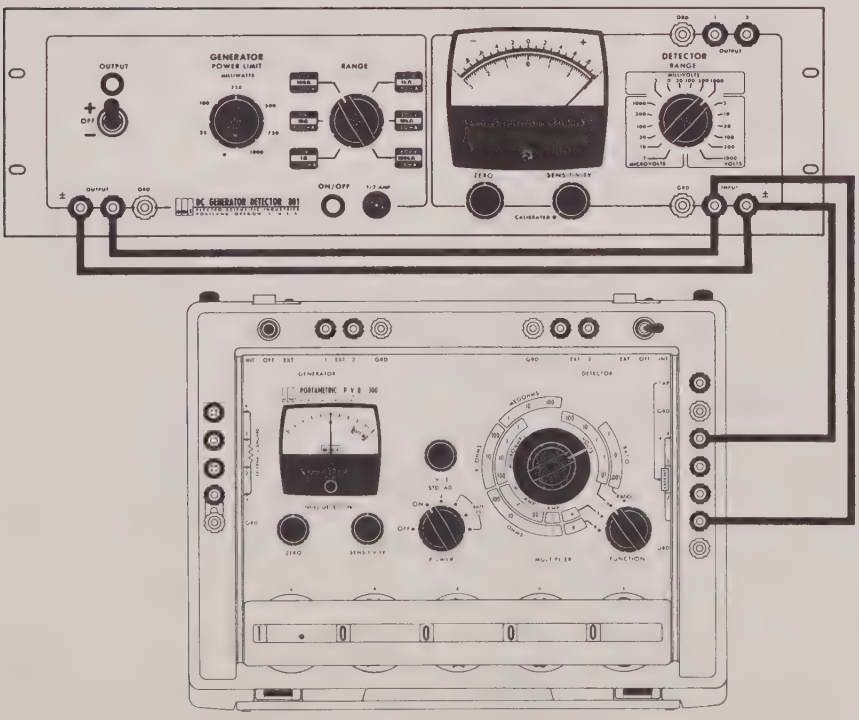

Figure 4.1b Detector Accuracy Test

4.2.2 Noise Performance Test

To determine whether detector noise is excessive, proceed as follows:

1. Short-circuit detector INPUT terminals.
2. Set detector RANGE control to 3 MICROVOLTS, and SENSITIVITY control to CALIBRATED.
3. Zero the detector.
4. Observe the meter for three successive 10-second periods. For at least one of these periods, the meter pointer should not vary more than 0.15 microvolt peak-to-peak; it should stay within a 3-minor-division interval.

4.2.3 Generator Voltage Check

Check on a one-year basis the output voltages for each generator range. This is done as follows:

1. Turn instrument on and allow 5 minutes to warm up.
2. Turn OUTPUT switch to OFF.
3. Set generator RANGE control to 1 ohm.
4. Set POLARITY to + .
5. Connect detector INPUT to generator OUTPUT terminals.
6. Set generator POWER LIMIT control to maximum.
7. Read voltage using the detector as a voltmeter.
8. Repeat all steps for all other settings of the generator RANGE control.

The voltages should be:

Range	Voltage
1Ω	1.6 to 2.4 V
10Ω	5.0 to 7.6 V
100Ω	10 to 24 V
1kΩ	50 to 76 V
10kΩ	160 to 240 V
100kΩ	500 to 760 V

4.2.4 Generator Leakage Resistance Check

To check the leakage resistance from each generator terminal to ground:

1. Connect jumper strap between detector INPUT terminal 1 and ground.
2. Connect generator OUTPUT terminal 1 to detector INPUT terminal 2 with shielded lead and plug.
3. Cover generator OUTPUT terminal with a grounded shield. Make sure that the shield does not touch the terminal.
4. Set detector SENSITIVITY control to CALIBRATED, and detector RANGE to 1000 MILLIVOLTS.

5. Set generator RANGE to 600 V, turn POWER LIMIT control fully clockwise, and set OUTPUT switch to + .
6. Meter should indicate less than 600 millivolts. (This indicates resistance greater than 10^{11} ohms.)
7. Set OUTPUT switch to OFF and connect generator OUTPUT terminal 2 to detector INPUT terminal 2 using shielded cable and plug. Again, as in test above, do not let plug touch terminal.
8. Set detector RANGE to 3 MICROVOLTS and generator RANGE to 600 V.
9. Set generator OUTPUT switch to + and turn POWER LIMIT control fully counterclockwise. Do not be concerned if meter indication goes off scale; it should be back on scale in a few seconds.
10. Within 30 seconds, the meter should indicate not more than 0.6 microvolt. (This indicates resistance greater than 10^{14} ohms.)

4.2.5 Detector Leakage Check

To check leakage resistance from each detector terminal to ground:

1. Disconnect any ground strap or jumper between either detector INPUT or OUTPUT terminals and ground.
2. Connect a jumper strap between generator OUTPUT terminal 2 and ground.
3. Connect generator OUTPUT terminal 1 to detector INPUT terminal 2 with a shielded lead and plug.
4. Cover detector INPUT terminal 1 with a grounded shield. Make sure that the shield does not touch the terminal.
5. Set detector SENSITIVITY control to CALIBRATED, and detector RANGE to 1000 MILLIVOLTS.
6. Turn generator RANGE and POWER LIMIT controls fully clockwise, and set OUTPUT switch to + .
7. Meter should indicate less than 600 millivolts. (This indicates resistance greater than 10^{11} ohms.)
8. Set OUTPUT switch to OFF and connect generator OUTPUT terminal 2 to detector INPUT terminal 1 using shielded cable and plug.
9. Set detector RANGE to 3 MICROVOLTS and generator RANGE to 600 V.
10. Set generator OUTPUT switch to + and turn POWER LIMIT control fully counterclockwise. Do not be concerned if meter indication goes off scale; it should be back on scale in a few seconds.
11. Within 30 seconds, the meter should indicate not more than 0.6 microvolt. (This indicates resistance greater than 10^{14} ohms.)

4.3 DETECTOR

4.3.1 Removing Inner Covers

The generator and the detector have inner covers to provide complete guarding and shielding of components. To remove the generator covers (top and bottom), remove the four screws holding each cover plate. To remove the detector cover, remove the two screws on the rear of the cover and slide the U-shaped cover backward, being careful not to scrape the circuit boards.

4.3.2 Servicing Etched Circuit Boards

CAUTION

REMOVE THE FIVE COLORED WIRES FROM
THE CIRCUIT CARDS IN THE DETECTOR
BEFORE UNPLUGGING THE CARDS.

The Model 801 has etched circuit boards. Use caution when removing them to avoid damaging mounted components. The assembly and Hewlett-Packard or ESI part number are on the circuit board to identify it.

The detector etched circuit boards are a plated-through type. The electrical connection between sides of the board is made by a layer of metal plated through the component holes. When working on these boards, observe the following general rules:

a) Use a low-heat (25 to 50 watts) small-tip soldering iron and a small-diameter rosen-core solder.

b) Circuit components can be removed by placing the soldering iron on the component lead on either side of the board and pulling up on lead. If a component is obviously damaged, clip leads as close to component as possible and then remove. Excess heat can cause the circuit and board to separate or cause damage to the component.

c) Component lead hole should be cleaned before inserting new lead.

d) To replace components, shape new leads and insert them in holes. Reheat with iron and add solder as required to insure a good electrical connection.

e) Clean excess flux from the connection and adjoining area.

f) To avoid surface contamination of the printed circuit, clean with weak solution of warm water and mild detergent after repair. Rinse thoroughly with clean water. When completely dry, spray lightly with Krylon (#1302 or equivalent).

4.4 ADJUSTMENT AND CALIBRATION

4.4.1 Mechanical Zero Adjustment

The mechanical zero adjustment is located on the instrument front panel. If the meter pointer does not indicate zero when the instrument power has been off for at least one minute, mechanically zero the meter by turning the screwdriver adjustment on the meter.

4.4.2 Electrical Zero Adjustment

The electrical zero adjustment should be performed when the meter pointer does not indicate zero on the 1000-millivolt range when instrument power has been on for at least one minute. No external equipment is required for this adjustment.

a) Set detector RANGE control to 1000 MILLIVOLTS.

b) Short-circuit INPUT terminals.

c) Remove the case; adjust A1R14 (1 V ZERO) for zero deflection on meter.

4.4.3 Full-Scale Calibration

The full-scale calibration consists of performing the 3 μV, 10 μV, 1 mV and 1 V adjustments.

a) Connect test setup illustrated in Figure 4.1a.

b) Remove the case

c) Set Potentiometric Voltmeter for 3 μV output; adjust A1R41 (3 μV) for full-scale deflection on 3 μV range.

d) Set Potentiometric Voltmeter for 10 μV output; adjust A1R42 (10 μV) for full-scale deflection on 10 μV range.

e) Set Potentiometric Voltmeter for 1 mV output; adjust A1R43 (1 MV) for full-scale deflection on 1000 μV range.

f) Set Potentiometric Voltmeter for 1 V output; adjust A1R44 (1 V) for full-scale deflection on 1000 mV range.

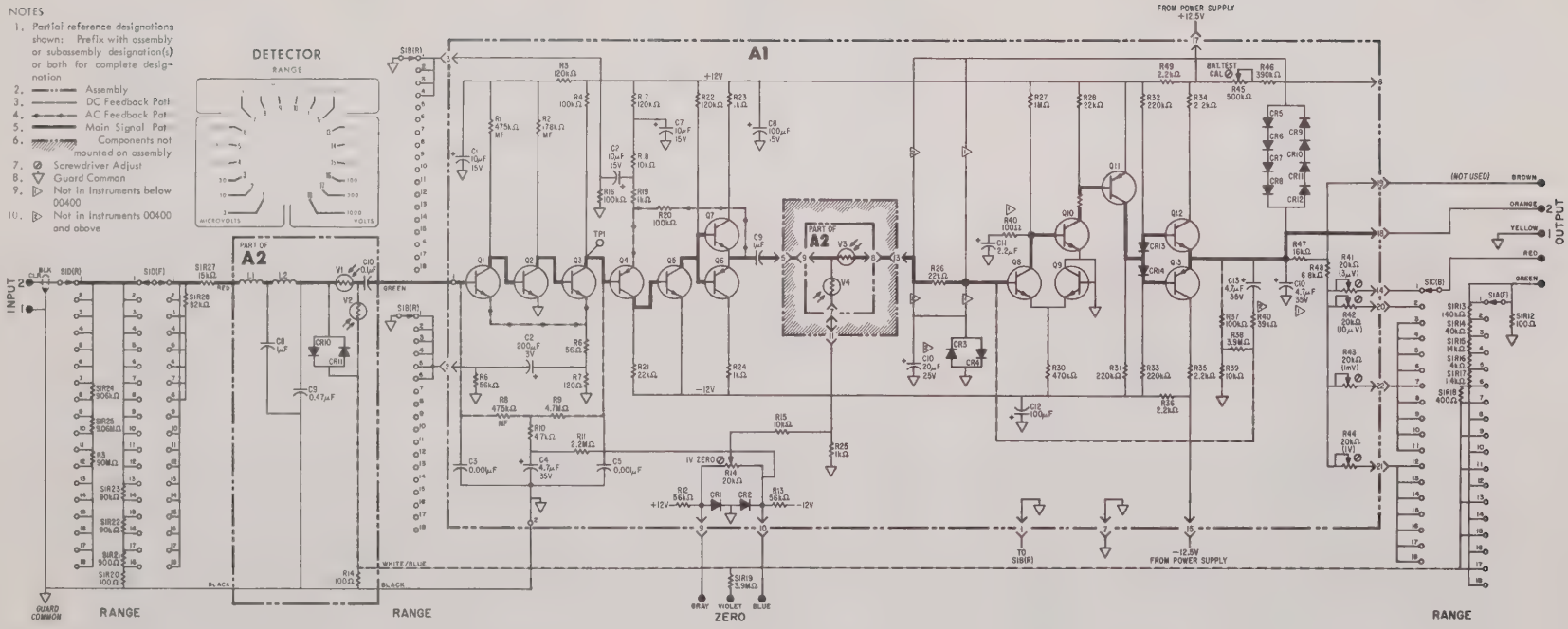

Figure 4.2 Detector, Schematic Diagram

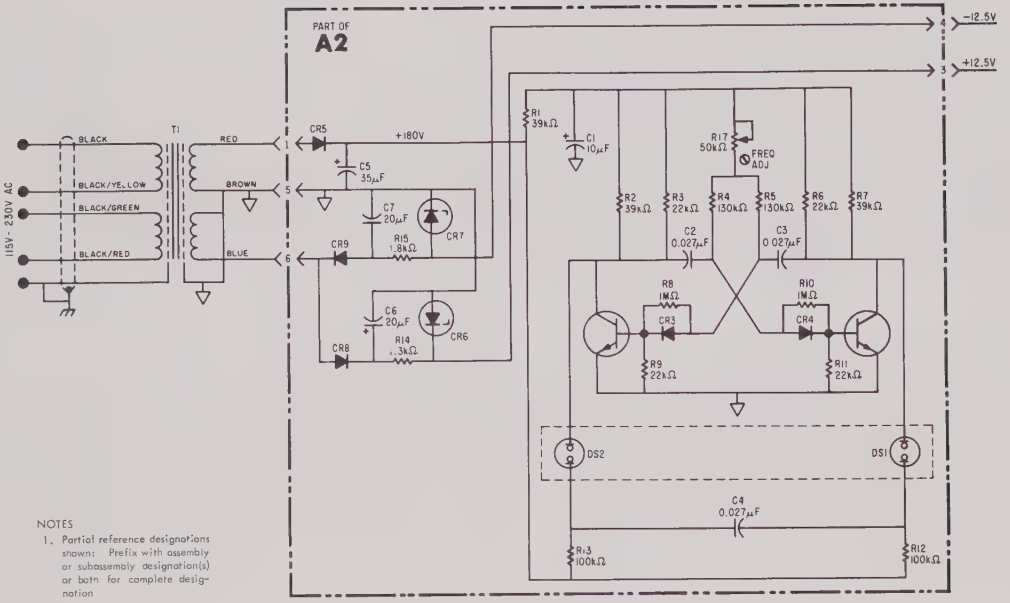

Figure 4.3 Detector Power Supply and Lamp Driver, Schematic Diagram

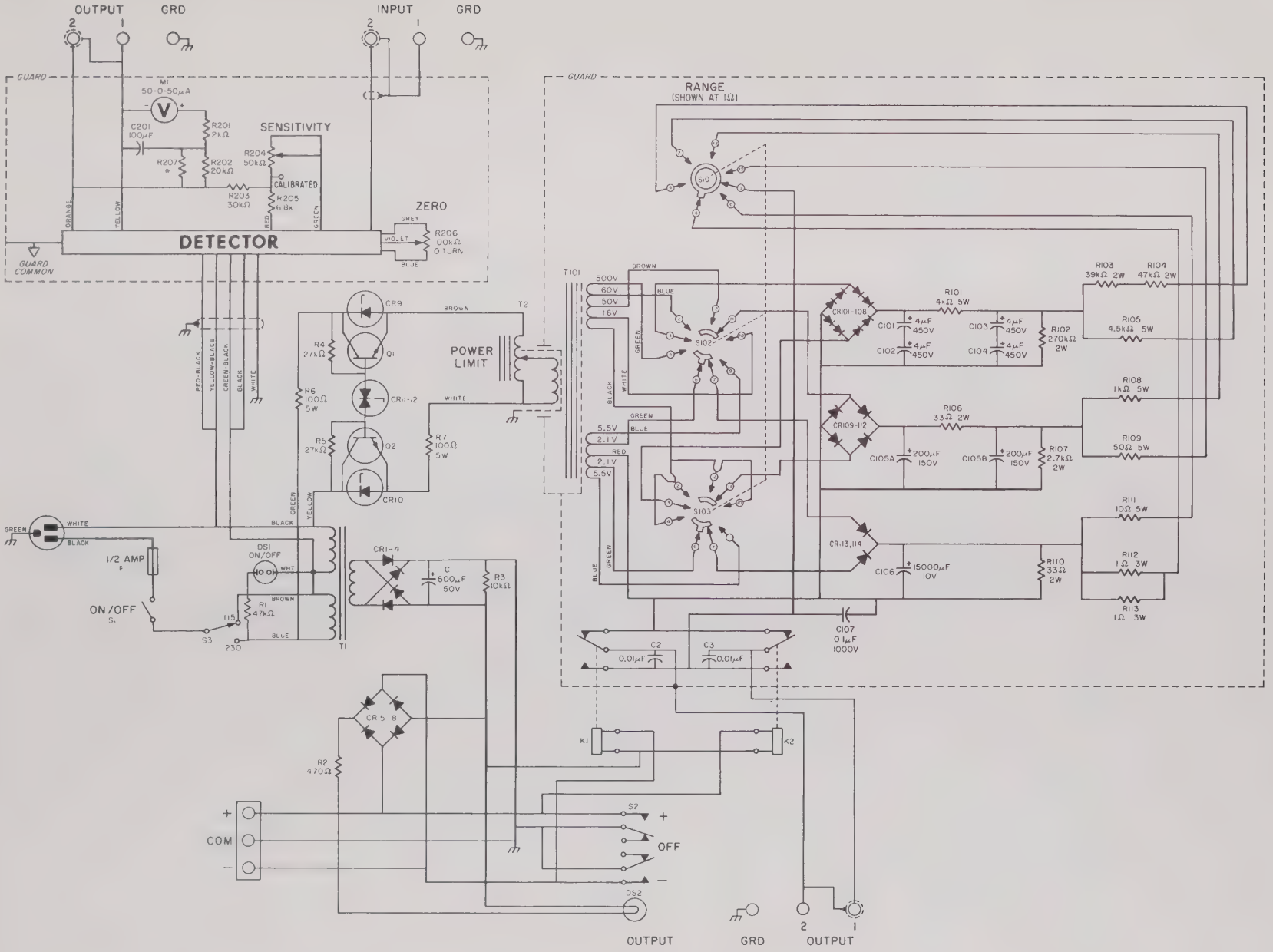

Figure 4.4 Schematic Diagram

4.5 PARTS LIST

The following parts list is in alpha-numerical order of the circuit reference designator. Miscellaneous parts are included at the end of the list. Manufacturer of the part is given in a code number according to the Federal Supply Code for Manufacturers (see list of manufacturers below).

Parts manufactured by Electro Scientific Industries must be ordered from the factory. When ordering, include the following information:

Model and serial number of the instrument
Electro Scientific Industries part number
Circuit reference designator
Description of part

CODE LIST OF MANUFACTURERS

00656	AEROVOX CORP., New Bedford, Massachusetts
01121	ALLEN BRADLEY COMPANY, Milwaukee, Wisconsin
01295	TEXAS INSTRUMENTS, INC., Dallas, Texas
02735	RADIO CORP. OF AMERICA, Somerville, New Jersey
03797	ELDEMA CORP., El Monte, California
04713	MOTOROLA, INC., Phoenix, Arizona
11837	ELECTRO SCIENTIFIC INDUSTRIES, INC., Portland, Oregon
12697	CLAROSTAT MFG. CO., Dover, New Hampshire
14655	CORNELL DUBILIER ELEC. CORP., South Plainfield, New Jersey
28480	HEWLETT-PACKARD COMPANY, Palo Alto, California
37942	P. R. MALLORY & CO., INC., Indianapolis, Indiana
56289	SPRAGUE ELECTRIC COMPANY, North Adams, Massachusetts
58474	SUPERIOR ELECTRIC COMPANY, Bristol, Connecticut
71482	C. P. CLARE, Chicago, Illinois
73138	BECKMAN INSTRUMENTS, INC., Helipot Division, Fullerton, California
73631	CURTIS DEV. & MFG. COMPANY, Milwaukee, Wisconsin
75915	LITTLEFUSE, INC., Des Plaines, Illinois
76487	JAMES MILLEN MFG. CO., INC., Malden, Massachusetts
76854	OAK MANUFACTURING CO., Crystal Lake, Illinois
82389	SWITCHCRAFT, INC., Chicago, Illinois

CKT REF	DESCRIPTION	MFR CODE	MFR PART NUMBER	ESI PART NUMBER	QTY USED
A1	Detector Amplifier Circuit Assembly	28480	00419-66501B	18409	1
A2	Detector Power Supply Circuit Assembly	28480	00419-66503	18408	1
C1	Capacitor, 500μF, 50V (-10% + 75%)	56289	39D507G050GL4	1942	1
C2, 3	Capacitor, 0.01μF, 1000V (±10%)	56289	41C121A1	1918	2
C101-104	Capacitor, 4μF, 450V (-10% + 100%)	00656	1710	2183	4
C105 A,B	Capacitor, 200μF, 150V (-10% + 75%)	14655	BR200-150	2138	2
C106	Capacitor, 18,000μF, (-10% + 75%)	37942	CG193U10D1	8035	1
C107	Capacitor, 0.1μF, 1000V (±10%)	00656	BE10P1	50013	1
C201	Capacitor, 100μF, 12V (-10% + 50%)	56289	TE1135	6157	1
CR1-8, 101-114*	Diode, Type IN4005 or Equal	04713	IN4005	1779	22
CR9, 10	Diode, Zener, 200 volts, 1 watt, 10%				2
CR11,12	Diode, Zener, 160 volts	04713	IN3049B	18453	2

** These apply to Figure 4.4 schematic only.*

CKT REF	DESCRIPTION	MFR CODE	MFR PART NUMBER	ESI PART NUMBER	QTY USED
DS2	Pilot Light, Generator OUTPUT	03797	CF03-RTS-176	18412	1
F1	Fuse, 1/2A	75915	3AG 1/2	1802	1
K1, 2	Relay, Guarded	71482	A-131142	18439	2
M1	Meter	11837	18410	18410	1
Q1, 2	Transistor, Type 40318 or Equal	02735	40318	18452	2
R206	Potentiometer, 100kΩ, 10 Turn, ZERO	12697	62JA	18414	1
R204	Potentiometer Switch Assembly, 50kΩ, SENSITIVITY	01121	JS-93392	18413	1
R1	Resistor, 47kΩ, 1/2 watt, 10%	01121	EB4731	1958	1
R2	Resistor, 470Ω, 1/2 watt, 10%	01121	GB4711	2056	1
R3	Resistor, 10kΩ, 1/2 watt, 10%	01121	EB1031	1961	1
R4, 5	Resistor, 27kΩ, 1/2 watts, 10%	01121	EB2731	1062	2
R6, 7	Resistor, 100Ω, 5 watts, 10%	12697	BC5E	1990	2
R101	Resistor, 4kΩ, 5 watts, 5%	12697	VC5E	2484	1
R102	Resistor, 270kΩ, 2 watts, 10%	01121	HB2741	1645	1
R103	Resistor, 39kΩ, 2 watts, 10%	01121	HB3931	2469	1
R104	Resistor, 47kΩ, 2 watts, 10%	01121	HB4731	2474	1
R105	Resistor, 4.5kΩ, 5 watts, 5%	12697	VC5E	2070	1
R106, 110	Resistor, 33Ω, 2 watts, 10%	01121	HP3301	2045	2
R107	Resistor, 2.7kΩ, 2 watts, 10%	01121	HB2721	2065	1
R108	Resistor, 1kΩ, 5 watts, 5%	12697	VPR5F-1K	2061	1
R109	Resistor, 50Ω, 5 watts, 5%	12697	VC5E-50Ω	2047	1
R111	Resistor, 10Ω, 5 watts, 5%	12697	VPR5F	2040	1
R112, 113	Resistor, 1Ω, 3 watts, 5%	12697	VC3D	2036	2
R201	Resistor, 2kΩ, 1/2 watt, 1%	00656	CPSX-1/2	2062	1
R202	Resistor, 20kΩ, 1/2 watt, 1%	00656	CPSX-1/2	1987	1
R203	Resistor, 30kΩ, 1/2 watt, 1%	00656	CPSX-1/2	2458	1
R205	Resistor, 6.8kΩ, 1/2 watt, 10%	01121	EB6821	2075	1
S1/DS1	Switch and Pilot Light Assembly ON/OFF	76854	616-26-A16	18418	1
S2	Switch, Lever, Generator OUTPUT	11837	3071	3071	1
S3	Switch, DPDT, (115-230)	82389	H6206LF	18424	1
S101-103	Switch, Generator RANGE	11837	8050	8050	1
T1	Transformer, Relay Supply	11837	18445	18445	1
T2	Variable Autotransformer, POWER LIMIT	58474	10B	8068	1
T101	Transformer, Generator	11837	8091	8091	1
	Barrier Strip, 3 Terminal	73631	GFTC-3	18415	1
	Binding Post, Guarded	11837	1480	1480	3
	Binding Post, 1 Inch Long	11837	1396	1396	6
	Cap, Binding Post, Black	11837	1170	1170	6
	Cap, Binding Post, Gold Plated	11837	1172	1172	6
	Detector Assembly	28480	00419	18411	1
	Dust Cover	11837	18446	18446	1
	Fuseholder	75915	342014	18416	1
	Generator Power Supply Assembly	11837	18420	18420	1
	Knob, Large Bar, Filled	11837	1266	1266	2
	Knob, Large Round, Filled	11837	1271	1271	1
	Knob, Small Round, Filled	11837	1268	1268	1

CKT REF	DESCRIPTION	MFR CODE	MFR PART NUMBER	ESI PART NUMBER	QTY USED
	Panel, Front	11837	18419	18419	1
	Power Cord	11837	2520	2520	1
	Printed Circuit Board Assembly, Capacitor	11837	18870	18870	1
	Printed Circuit Board Assembly, Diode	11837	18435	18435	1
	Printed Circuit Board Assembly, Meter	11837	18449	18449	1
	Printed Circuit Board Assembly, Relay Power	11837	18437	18437	1
	Shaft Coupler, Insulating	76487	39002	8052	2
	Slides	11837	82579	82579	2

Electro Scientific Industries, Inc.

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PORTLAND, OREGON 97229
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WARRANTY OF TRACEABILITY

Electro Scientific Industries, Inc. maintains reference standards of measurement which are compared with the U. S. National Standards through frequent tests by the U. S. National Bureau of Standards.

ESI working standards and testing apparatus used are calibrated against the ESI reference standards in a rigorously maintained program of measurement control.

The manufacture and final calibration of all ESI instruments are controlled by use of the ESI reference and working standards and testing apparatus in accordance with established procedures and documented results. (Reference MIL-C-45662)

Final calibration of this instrument was performed with reference to the mean values of the ESI reference standards or to ratio devices that were verified at the time and place of use.

esi® Part No. 1866 7-70

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WARRANTY OF QUALITY

Electro Scientific Industries, Inc. warrants its products to be free from defects in material and workmanship for the following periods:

1. Two years for components and instruments using passive circuitry. One year for repairs of out-of-warranty items.
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During the in-warranty periods, we will service or, at our option, replace any device that fails in normal use to meet its published specifications. Batteries, tubes and relays that have given normal service are excepted.

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There is a complete bibliography of ESI technical publications on the opposite side of this page. Underline the titles or order numbers of any publications you would like us to send. If there is any information that you would like to have, or if there is any comment you would like to make concerning the instrument or instruction manual, please fill out this page.

Instrument Description: Model No. _____ Serial No. _____
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Any comments or corrections? _____

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